

WHAT IS CLAIMED IS:

1 1. A method of filling a gap defined by adjacent raised features on a
2 substrate, comprising:
3 providing a flow of a silicon-containing processing gas to a chamber housing
4 the substrate;
5 providing a flow of an oxidizing processing gas to the chamber;
6 providing a flow of a phosphorous-containing processing gas to the chamber;
7 depositing a first portion of a P-doped silicon oxide film as a substantially
8 conformal layer in the gap by causing a reaction between the silicon-containing processing
9 gas, the phosphorous-containing processing gas, and the oxidizing processing gas, wherein
10 depositing the conformal layer comprises varying over time a ratio of the (silicon-containing
11 processing gas plus phosphorous-containing processing gas):(oxidizing processing gas) and
12 maintaining the temperature of the substrate below about 500°C throughout deposition of the
13 conformal layer; and
14 thereafter, depositing a second portion of the P-doped silicon oxide film as a
15 bulk layer, wherein depositing a second portion of the film comprises maintaining the ratio of
16 the (silicon-containing processing gas plus phosphorous-containing processing
17 gas):(oxidizing processing gas) substantially constant throughout deposition of the bulk layer
18 and maintaining the temperature of the substrate below about 500°C throughout deposition of
19 the bulk layer.

1 2. The method of claim 1, further comprising:
2 thereafter, patterning metal lines on the substrate over the P-doped silicon
3 oxide film; and
4 maintaining the temperature of the substrate below a reflow temperature of the
5 P-doped silicon oxide film from a point in time immediately after deposition of the bulk layer
6 to a point in time after patterning metal lines on the substrate.

1 3. The method of claim 2, wherein maintaining the temperature of the
2 substrate below a reflow temperature of the P-doped silicon oxide film from a point in time
3 immediately after deposition of the bulk layer to a point in time after patterning metal lines
4 on the substrate comprises not annealing any portion of the substrate.

1 4. The method of claim 1, wherein the substrate comprises nickel silicide
2 connectors and the P-doped silicon oxide film comprises a pre-metal dielectric layer.

1 5. A method of filling a gap defined by adjacent raised features on a
2 substrate, comprising:

3 providing a flow of a silicon-containing processing gas to a chamber housing
4 the substrate;

5 providing a flow of an oxidizing processing gas to the chamber;

6 depositing a first portion of a silicon oxide film as a substantially conformal
7 layer in the gap by causing a reaction between the silicon-containing processing gas and the
8 oxidizing processing gas, wherein depositing the conformal layer comprises varying over
9 time a ratio of the (silicon-containing processing gas):(oxidizing processing gas) and
10 maintaining the temperature of the substrate below about 500°C throughout deposition of the
11 conformal layer;

12 thereafter, depositing a second portion of the silicon oxide film as a bulk layer,
13 wherein depositing a second portion of the film comprises maintaining the ratio of the
14 (silicon-containing processing gas):(oxidizing processing gas) substantially constant
15 throughout deposition of the bulk layer and maintaining the temperature of the substrate
16 below about 500°C throughout deposition of the bulk layer; and

17 thereafter, depositing a cap layer comprising a P-doped silicon oxide film
18 while maintaining the substrate below about 500°C throughout deposition of the cap layer.

1 6. The method of claim 5, further comprising:

2 thereafter, patterning metal lines on the substrate over the P-doped silicon
3 oxide film; and

4 maintaining the temperature of the substrate below a reflow temperature of
5 either the silicon oxide film or the P-doped silicon oxide film from a point in time
6 immediately after deposition of the bulk layer to a point in time after patterning metal lines
7 on the substrate.

1 7. The method of claim 6, wherein maintaining the temperature of the
2 substrate below a reflow temperature of either the silicon oxide film or the P-doped silicon
3 oxide film from a point in time immediately after deposition of the bulk layer to a point in

4 time after patterning metal lines on the substrate comprises not annealing any portion of the
5 substrate.

6 8. A method of processing a semiconductor substrate, comprising:
7 providing a flow of a silicon-containing process gas to a chamber housing the
8 substrate;
9 providing a flow of an oxidizer process gas to the chamber;
10 causing a reaction between the silicon-containing process gas and the
11 oxidizing process gas to form a silicon oxide layer on the substrate;
12 varying over time a ratio of the (silicon-containing gas):(oxidizing gas) flowed
13 into the chamber to alter a rate of deposition of the silicon oxide on the substrate; and
14 maintaining the substrate at or below a reflow temperature of the silicon oxide
15 layer throughout processing of the semiconductor substrate.

1 9. The method of claim 8, wherein maintaining the substrate at or below a
2 reflow temperature of the silicon oxide layer throughout processing of the semiconductor
3 substrate comprises not annealing the substrate.

1 10. The method of claim 8, wherein the silicon oxide layer comprises a
2 pre-metal dielectric layer.

1 11. The method of claim 8, wherein the substrate comprises a gap between
2 adjacent surfaces, and wherein the silicon oxide is deposited in the gap.

1 12. The method of claim 8, wherein the substrate comprises nickel silicide.

1 13. The method of claim 8, further comprising providing a flow of a
2 phosphorous-containing process gas to the chamber during a time period, wherein the flow of
3 silicon-containing process gas is provided at least partly during the time period.

1 14. The method of claim 13, wherein the silicon-containing process gas
2 comprises TEOS and wherein the phosphorous-containing process gas comprises TEPO.

1 15. The method of claim 13, further comprising:
2 thereafter providing a subsequent flow of phosphorous-containing process gas
3 to the chamber.

1 16. The method of claim 15, further comprising, while providing the
2 subsequent flow of phosphorous-containing process gas to the chamber, regulating a pressure
3 of the chamber to a pressure in a range from about 200 torr to about 760 torr.

1 17. The method of claim 15, further comprising, while providing the
2 subsequent flow of phosphorous-containing process gas to the chamber, forming a plasma
3 from the phosphorous-containing process gas.

1 18. The method of claim 17, wherein the plasma has a density greater than
2 about 10^{11} ions/cm³.

1 19. A method of processing a semiconductor substrate, comprising:
2 providing a flow of a silicon-containing process gas to a chamber housing the
3 substrate;
4 providing a flow of an oxidizing process gas to the chamber;
5 providing a flow of a phosphorous-containing process gas to the chamber;
6 causing a reaction between the silicon-containing process gas, the oxidizing
7 process gas, and the phosphorous-containing gas to form a P-doped silicon oxide layer on the
8 substrate; and
9 varying over time a ratio of the (silicon-containing gas):(oxidizing
10 gas):(phosphorous-containing gas) flowed into the chamber to alter a rate of deposition of the
11 silicon oxide on the substrate.

1 20. The method of claim 19, further comprising maintaining the substrate
2 at or below at reflow temperature of the P-doped silicon oxide layer.

1 21. The method of claim 19, wherein the substrate comprises a gap
2 between adjacent surfaces, and wherein the silicon oxide is deposited in the gap.

1 22. The method of claim 19, wherein the P-doped silicon oxide layer
2 comprises a pre-metal dielectric layer.

1 23. The method of claim 19, wherein the substrate comprises nickel
2 silicide.

- 1 24. The method of claim 19, wherein the silicon-containing process gas
2 comprises TEOS and wherein the phosphorous-containing process gas comprises TEPO.
- 1 25. The method of claim 24, further comprising:
2 thereafter providing a subsequent flow of phosphorous-containing process gas
3 to the chamber.
- 1 26. The method of claim 25, further comprising, while providing the
2 subsequent flow of phosphorous-containing process gas to the chamber, regulating a pressure
3 of the chamber to a pressure in a range from about 200 torr to about 760 torr.
- 1 27. The method of claim 25, further comprising, while providing the
2 subsequent flow of phosphorous-containing process gas to the chamber, forming a plasma
3 from the phosphorous-containing process gas.
- 1 28. The method of claim 27, wherein the plasma has a density greater than
2 about 10^{11} ions/cm³.